



Growing Quality Green Jobs

Driving Economic Advancement in the Green Economy

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Acknowledgments

This report has been made possible by the support of the Ares Charitable Foundation as part of its Climate-Resilient Employees for a Sustainable Tomorrow (CREST) initiative.

The authors would like to recognize several individuals and partners for their time and expertise in making this report possible. Many thanks to colleagues at the Burning Glass Institute, including Matt Sigelman, Erik Leiden, Luke Chen, and Vivek Sampathkumar, for their thought leadership in helping to shape the overall data framework of this report, and to the World Resources Institute for its partnership in the collective work around a just transition to a green economy.

We also appreciate the endless support and assistance of our JFF colleagues, in particular JFF's Climate Innovation leadership and project team, all of whom made this report stronger through their thorough, consistent feedback and review.

Finally, we give special thanks and gratitude to Armando Acosta, Athena Valenzuela, Jeffrey Cleveland, Mark Hall, and Rafael Aguilera for sharing their time and their insights, perspectives, and expertise on the evolving green jobs landscape.

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The Ares Charitable Foundation is a 501(c)(3) qualifying organization sponsored by Ares Management Corporation, a leading global alternative investment manager. Established in 2020, the Ares Foundation expects to achieve sustained, measurable impact through strategic investments on a global basis in nonprofit programming that provides career preparation and reskilling, encourages entrepreneurship, and deepens individuals' understanding of personal finance so that people can pursue a better future.

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About Climate-Resilient Employees for a Sustainable Tomorrow (CREST)

CREST is a five-year, \$25 million career preparation and reskilling initiative of the Ares Charitable Foundation (the "Ares Foundation") that aims to help close the gap between the demand for a skilled workforce for green jobs and the number of people prepared for these opportunities. Working with our partners and local communities, the Ares Foundation can deepen our impact, harness new opportunities, and help create a green, resilient future that benefits generations to come.

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Introduction

Combating climate change and the ripple effects of its impact is one of the major imperatives of our time. As extreme weather, resource shortages, and other challenges worsen, the U.S. economy is gradually shifting in response. While demand is increasing for well-known green job roles such as solar photovoltaic installer, environmental scientist, and electric vehicle technician, there are currently only 900,000 estimated green jobs within the United States, representing just 0.6% of the workforce.¹ They also represent sectors that lack critical representation from the populations that climate change is hurting the most: people from low-income communities, people of color, and people from rural areas.²

Indeed, it's becoming increasingly clear that our country faces multiple, interrelated climate challenges. A transition to a green economy is not happening quickly enough to minimize significant health hazards brought on by climate change, nor is it building equitable resilience against devastating and ongoing natural disasters impacting communities nationwide. Emerging green jobs that could provide a foundation for change—particularly those that demand science, technology, engineering, and math skills—tend to require at least a bachelor's degree and lack entry-level roles or clear pathways for people from underserved and underrepresented populations.² A truly just transition to a green economy requires solutions that not only limit the root causes of our warming planet but also lead to accessible, equitable, and quality jobs for a sustainable future.³

The Green Transformation Cycle, a new data-driven framework developed by JFF in partnership with the Burning Glass Institute (BGI), is intended to support our nation's progress to a green economy by prioritizing environmental sustainability as well as equitable economic advancement. Underpinning the framework is, first and foremost, an expansive look at green jobs and the skills shaping them. Our innovative approach—based on an analysis of nearly 200 million online job postings—demonstrates that when the integration of current green skills into various

occupations is considered, green jobs are more prevalent than commonly thought. Application of this framework shows that many jobs that have not historically been considered green have, in fact, integrated green skills. It reveals how bold actions based on this new understanding of how green skills transform jobs can both lead to more opportunities in the future green economy while also demonstrating the need to prepare workers to fill these roles. And it identifies ways to ensure that we move toward quality green jobs that provide not only a living wage and benefits but also job stability, flexibility, autonomy, and advancement.⁴

This report intends to leverage the Green Transformation Cycle to illustrate the economic transformation currently underway, and to better shape workforce training programs, employer talent pipelines, and emerging green economy legislation to support the urgency of a just transition to a green economy.⁵ Additional personal insights from workers and experts we interviewed who are navigating the green economy firsthand, along with an informed exploration of job quality, skills training, and other trends in their fields, contribute to our final recommendations.

Ultimately, we contend that to fully understand how to promote a just transition, it is important to move beyond the binary conception of jobs as being either “green” or “not green.” Rather, it’s more useful to think of green jobs on a continuum—one that will continue evolving and will grow to include all jobs over time. Some jobs are deeply green, based on their sector or direct organizational role in environmental and sustainability initiatives. Other jobs may not be specific to climate sectors but still incorporate green skills contributing, in aggregate, to substantial positive effects on the environment. Workforce development leaders and other key stakeholders should therefore strive to transform all jobs into quality green jobs to achieve a just transition to an equitable green economy. We believe our future depends on it.



What Are Green Skills, and Why Do They Matter?

Green skills are traditionally understood as the knowledge, competencies, and abilities necessary to engage in job tasks focused on climate mitigation efforts that power the green economy.⁶ However, skills like solar panel installation, pollution reduction, and environmental planning can influence and impact jobs beyond traditional green industry occupations. In fact, many jobs across a wide variety of industries not typically considered green increasingly require some green skills and contribute significantly to the greening of the economy, according to our analysis.

Exploring how new skills are integrated into jobs and applying the process to what we know about job transformation provides a new way to predict which jobs are most likely to grow in a green economic transformation. This information is crucial for supporting education and training providers, workforce developers, employers, and workers themselves to determine how to respond to the ongoing transformation. *(See Appendix A for our analysis methodology and examples of green skill integration.)*

Our research uncovered three levels of green skill integration: **additive**, **blended**, and **job-changing**. *(See Table 1.)* Jobs at the additive level gain a small subset of new green skills within a broader set of responsibilities but maintain traditional overall roles and functions. Jobs at the blended level adopt broader sets of new green functions within existing roles and thus start to evolve. At the job-changing level, roles undergo a significant shift in skill sets; roles and functions are completely changed due to their full integration of green skills.

TABLE 1

Levels of Green Skill Integration

Additive	Jobs gain new green skills while maintaining traditional overall roles and functions.
Blended	Job roles and functions start to evolve as they gain new green skills.
Job-Changing	Job roles and functions are completely changed due to their full integration of green skills.

Additive

One example of a job at the additive level of green skills integration is network and computer systems administrator, an occupation that exists across industries, from those that are typically not considered green, such as finance, to the very green, such as clean energy. Mentions of green skills in online job postings related to this role, which focuses primarily on managing large, networked computer systems, increased more than 35% from 2018 to 2022.⁷ This is one of the larger greening transitions identified in our analysis of green skill trends. Examples of green skills in these roles include energy management, energy conservation, and building environmental automation systems. While the change in skill content reflects only a small portion

of the job responsibilities, the collective impact of the large number of jobs with these skills may have a profound effect on the environment as well as economic opportunity.

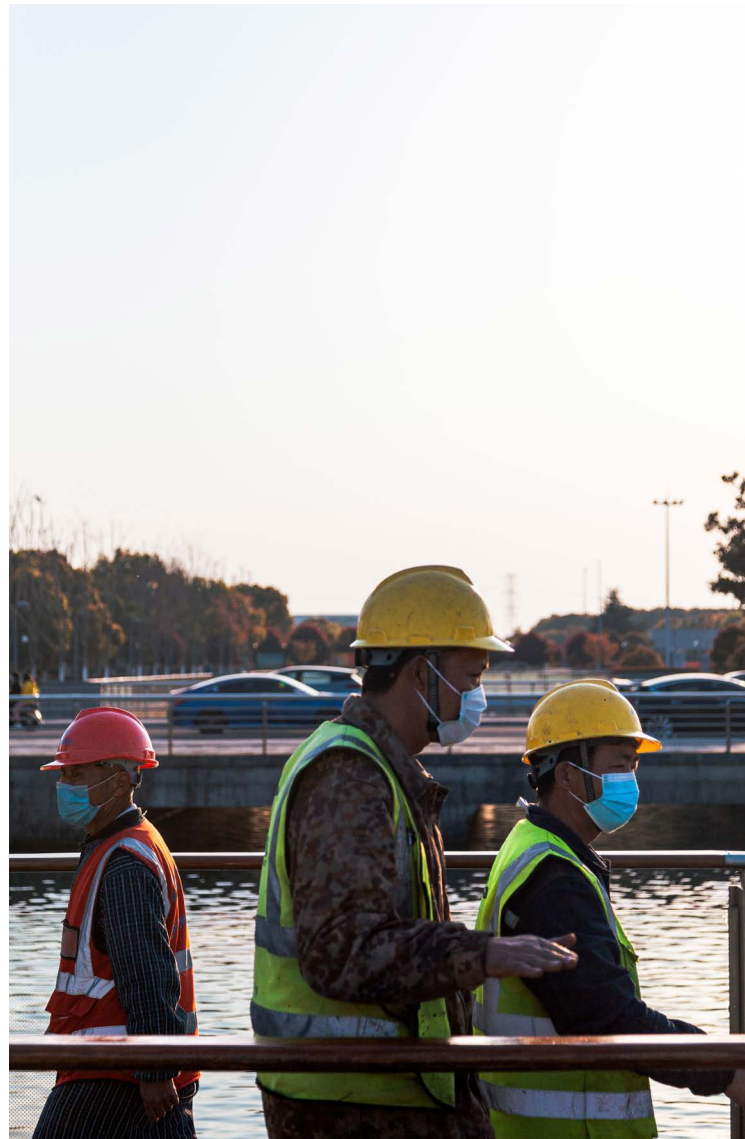
Blended

One example of a job at the blended level of green skills integration is machinery maintenance technician, which is bridging traditional job responsibilities with emerging green skills. This role combines traditional aspects of the job revolving around power plant maintenance and power production with maintaining high-tech machinery that runs complex heating and cooling systems or helps build and maintain more effective water treatment facilities. The emerging green skills in this role include those that

augment more traditional skills to build environmentally friendly and more energy efficient practices into the role, such as energy conservation and overall energy management.

Job-Changing

The transportation sector is increasingly incorporating more efficient and environmentally conscious technologies. One example of a role at the job-changing level of green skills integration is transportation, logistics, and shipping manager, which has seen a marked increased demand for green skills—an increase of 9.2 percentage points in the share of skills that are in demand for the role. Growth in demand for green skills in the role is largely related to understanding and managing stormwater. This is likely due to factors such as increased awareness of the ways in which transportation and logistics are interconnected with broad water systems. Transportation and shipping managers are at the front lines of understanding, responding to, and mitigating impacts from increasingly common storm events to ensure the reliability of transportation and logistics providers.



Why We Need a New Skills-Based Definition of Green Jobs

The current definitions of green jobs are further complicated when we consider juxtaposing current green jobs and industries with the environmental and social impacts they can have. The increase in demand for electric vehicles and the parallel environmental destruction caused by intensive mining to source battery materials are two examples. Large-scale solar projects and renewable-energy mining often come with a significant cost to Indigenous people and their land, threaten endemic flora and fauna, and open opportunities for human rights violations such as forced labor for both adults and youth.⁸

U.S. cities that have implemented policies to encourage climate-resilient practices and infrastructure have also experienced increased gentrification, displacing low-income communities of color as a result. To only consider apparent green sectors ignores these impacts and masks the potential domino effects that must also be mitigated not only to be green but to be equitable and sustainable. By thinking about all jobs and their contributions to climate change, we are able to look at outcomes together to see a contextualized, fuller picture and understand and plan for both the benefits and the harms.

Now over a decade old, most definitions of green jobs are outdated and only reflect roles within traditionally green industries. A just transition to a green economy—one that embodies reduced environmental impact and sustainable development—requires stronger, evidence-based criteria to define green jobs and to design and assess effective policy solutions to support their advancement over the long term. A new, more expansive way of thinking about green jobs must incorporate the broader understanding of green skills described above, as well as measures of job quality and access.

“What defines a climate workforce? Is it solely comprised of clean energy and clean water, or should it encompass diverse sectors like agriculture, manufacturing, healthcare, and education? We advocate that all jobs embrace strong green practices and sustainability principles. Our overall objective is to foster workforce solutions that tackle climate change, reduce poverty, and promote equity in tandem. With this approach, we can simultaneously foster sustainable economic growth, improve wages, and support local employers.”¹¹

- Rafael Aguilera

Field Specialist, High Road Training Partnerships
- California Workforce Development Board

To date, the U.S. Bureau of Labor Statistics (BLS) and the United Nations Environment Programme (UNEP) have led the conversation around defining green jobs, particularly concerning specific industries and sectors, such as clean energy and natural resource conservation. (See Appendix B for the BLS and UNEP definitions.) While jobs in these select industries may focus on mitigating the effects of climate change on a macro level and typically offer strong salaries,

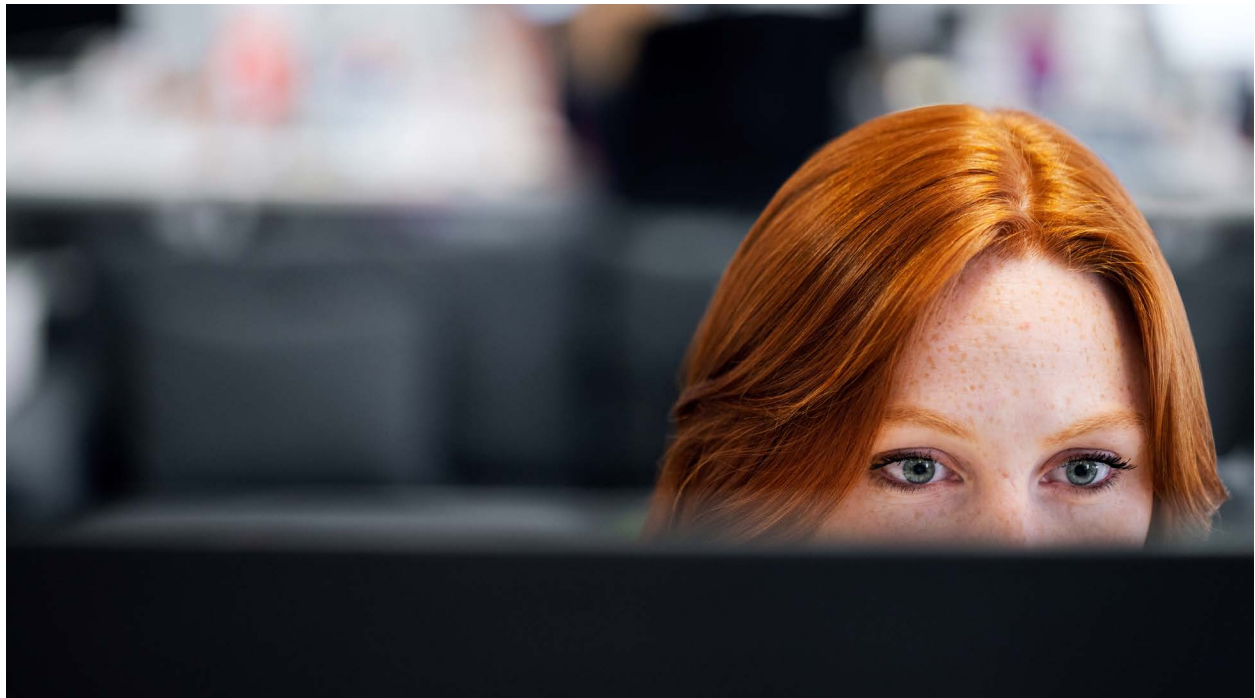
a just transition must involve a more diverse set of industries, strong job-quality measures, and career pathways that are broadly accessible to the people currently underrepresented in the green economy.⁸ For example, less than 20% of workers in the clean energy production and energy efficiency sectors are women, and Black workers fill less than 10% of jobs in these sectors.⁹

How Should Green Jobs Be Defined?

The BLS and UNEP definitions expanded the aperture of what could be considered a green job, to keep pace with the effects of climate change on business sectors and economies worldwide. Today, trends they recognized are ongoing, and an even greater number of jobs, spanning many industries, have undergone—or are likely to undergo—what we refer to as a *green transformation*.¹⁰ In these jobs, green skills are emerging and shaping roles and responsibilities across a range of jobs and industries as our economy continues to become more climate friendly.

We believe that our nation ultimately has the potential to transform all jobs, spanning all industries, into quality green jobs, through the intentional adoption and integration of green skills and the prioritization of job quality. Key workforce development players—employers, training providers, policymakers, local and state workforce boards, community-based organizations, and others—must take the lead.

A just transition to a green economy is not simply a semantic shift—a change in definition—however. It will require a substantial shift in the traditional roles and expertise of workers across all industries, as explained in the next section.





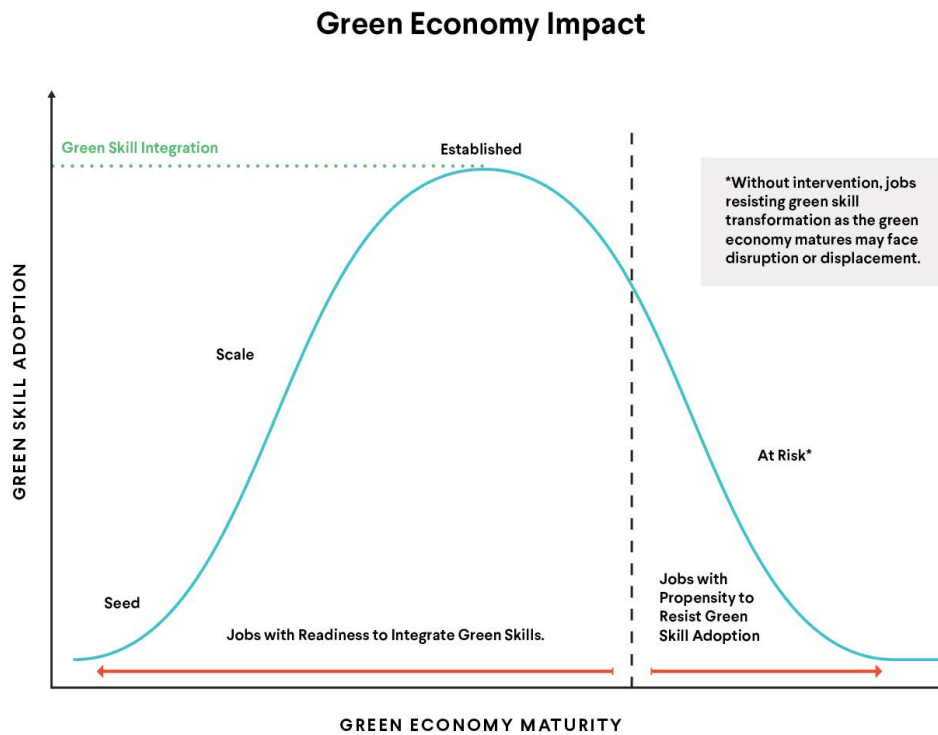
The Green Transformation Cycle

To better understand the green economy and the evolution and growth of its skills and occupations, JFF and BGI developed a data analysis framework called the Green Transformation Cycle. The framework was designed by applying concepts of product lifecycle theory—how investments grow and the adoption of innovations scale—to the green economic transformation that is underway.¹² Individual green skills, individual green jobs, and the green economy itself can be viewed similarly to new products at different stages of maturity. Like new inventions that often have a long lead time before they become widely adopted, the expansion of green skills, green jobs, and the green economy will require a long trajectory of early small-scale adoption followed by rapid and, ultimately, more stable growth.

We believe that this model will help drive a deeper and more nuanced understanding of a just transition to a green economy. We envision several stages of green skill adoption—seed, scale, established, and at risk—to show the extent to which green skills are in use in each job stage. (See *Figure 1*.) Furthermore, we can apply this model to recent labor market information and highlight both current and emerging green skills and green jobs.

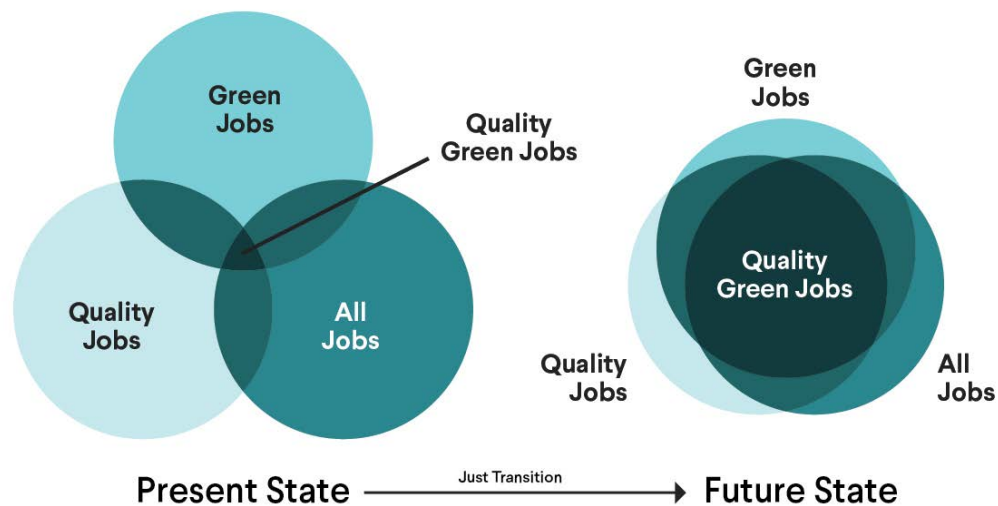
FIGURE 1

Levels of Green Skill Integration



What we refer to as the Green Transformation Cycle helps us move from asking questions such as “How many green jobs are there?” or “Which industries are green?” to instead explore other questions:

✓	What new green skills and jobs are emerging?
✓	What green skills growth is taking place in existing jobs, and how are these skills shaping green jobs?
✓	What green skills and jobs are scaling and approaching adoption?
✓	What green skills and jobs are established within and outside of what have traditionally been considered green jobs and simultaneously offer a living wage?
✓	What stage of disruption or decline are certain jobs—both green and not green—experiencing?
✓	What can workforce training providers, policymakers, and employers do to advance quality green jobs for a just transition to a green economy?



Applying the Green Transformation Cycle to Skills and Jobs

Taking traditional definitions for green jobs, including those of the BLS or UNEP, and applying them to data sources to identify green jobs gives us valid but limited results. Pursuing other emerging models that solely consider green sectors or traditional green skills, such as the University of California, Berkeley’s state-level project on green job creation, yields similar results.¹³ The Green Transformation Cycle allows us to explore traditionally green jobs (such as solar panel installer and wind turbine technician) and also consider the jobs that are starting to require more green skills (such as computer network specialist) to better analyze labor market information.

In conducting our analysis, first we explored how jobs are changing based on the extent to which they must integrate green skills—and, as explained above, we categorized the different levels of

integration as additive, blended, or job-changing. In addition to describing the extent to which green skills have been integrated into jobs not traditionally seen as green, our framework maps the level of integration against four distinct stages of green job transformation: seed, scale, established, and at risk. (See *Table 2*.)

Based on the premise that all jobs have the potential to be green, we believe that this framework can be applied to present opportunities for targeted intervention based on their categorization and can be leveraged to identify which jobs and skills are leading the transition to a green economy. Note also that this framework is not meant to quantify change or the volume of roles at risk but is instead intended to increase our understanding of the nature of transformation and serve as part of a toolkit to aid decision-making for furthering green jobs in a changing economy. A more detailed explanation of the methodology and application of this framework is available in Appendix A.

TABLE 2

Stages of Green Job Transformation

Job Stage	Description	Most Likely Level of Green Skill Integration
Seed	Jobs and associated skills that are in early economic adoption.	Additive
Scale	Jobs and associated skills that are showing early and significant-enough economic growth to indicate signs of scaling.	Blended
Established	Jobs that have established green and associated skills that are commonly seen in our workforce.	Blended
At Risk	Jobs and associated skills that are showing inverse trends for green job adoption.	Job-Changing





Seed

Seed stage refers to jobs and skills that are currently in an early-adoption phase but show promise for significant economic growth and an increasingly positive trajectory of future demand and adoption. Related roles include fuel cell engineer, tidal energy project manager, or hydrogen commissioning technician. In other words, this category will look traditionally green but can also include broader and more general occupations like engineer, project manager, or heavy machinery technician, respectively. These jobs or skills may show potential for significant economic growth, but it is too early to tell what their trajectories will be.



Scale

Scale stage refers to jobs or skills that have shown early and significant growth; workers are increasingly adopting these skills, for which demand is growing exponentially across roles and industries. Examples of green jobs in the scaling stage include solar panel installer and sales and wind turbine maintenance technician. Jobs that are quickly adopting green skills and seeing similar growth trajectories include wastewater manager, structural systems installer, quality control analyst, machinery maintenance worker, and computer user support specialist. In general, these job opportunities are increasing.

Stages of Green Job Transformation



Established

Established green jobs are ones that have largely integrated green skills and support the overall shift toward a low-carbon economy. They are frequently identified as established roles in the green job sector across many industries. A wide range of occupations are in the established stage, including executive level-roles, like chief sustainability officer, and frontline jobs, like forest conservation technician and energy auditor. Somewhat unexpected roles appear in the established stage, such as transportation manager and electrician. To stay eligible for these types of jobs, they must continue to grow their green knowledge in these areas.



At Risk

At-risk jobs are experiencing inverse trends in green skill adoption. These jobs, such as oil and gas service unit operator, pump operator, and power plant operator, are exceptionally vulnerable to displacement or disruption in the emerging green economy. There is a high likelihood that many workers will need to transition to new roles and others will see significant shifts in the overall skill content of their roles—in some cases toward green skills. Workers who remain in these roles must develop competence with green skills to remain relevant and avoid displacement. Deep job pathway interventions are needed to support these workers' transition to the green economy in the short and long terms.

Measuring Job Quality Within the Green Transformation Cycle

This framework provides a lens through which to consider the various trajectories of jobs transforming through emerging skills and knowledge that broaden the scope of what we consider green. However, as previously discussed, job quality is an important consideration—one that is integrated within our framework. The future of green jobs presents an opportunity to disrupt traditional methods of analysis to instead focus on roles that are more accessible to low-income communities and people of color, who are vastly underrepresented in the green economy.¹⁴ This leads us to our next set of criteria, which further refines green jobs with an eye toward a just transition. Using common but not exhaustive measures of job quality, we filtered green jobs identified in the framework across three data points:

- **Access:** What are the educational and/or professional requirements for the job? What credentials are required for this job? Is a job generally accessible with limited years of professional experience?
- **Wage:** Prioritizing a family-sustaining wage, generally defined in this paper as the income needed to support a minimum of one adult and one dependent, does the median salary come within 5% of \$25 an hour or \$50,000 a year?¹⁵
- **Growth:** What is the anticipated employment growth for each job, with growth defined as overall employment growth in the occupation? We use the BLS Occupational Outlook Handbook's 10-year employment projections to estimate growth. This is an imperfect measure but gives a sense of the overall economic conditions for the occupation.



Table 3 showcases a sample of jobs that our analysis identified as among those incorporating the highest number of green skills. The current greenest roles in the economy—those that are largely, unquestionably, and squarely in the greenest portions of the labor market, such as chief sustainability officer or solar panel sales representative—command significant attention among researchers, policymakers, and the media. While in some cases these roles offer a competitive salary, many are limited in their accessibility to all workers because they

require a four-year degree and previous work experience. Similarly, they present less opportunity for overall employment at scale. They largely adopted green skills, achieved steady growth, and represent a very small volume of jobs overall. In other words, many workers cannot access these jobs, and if they do, they will likely face significant barriers to advancement, a key pillar of job quality. Additionally, the reach of these green jobs is limited to the green sector, and they do not cut across industries in a general way.



TABLE 3

Sample of Green Jobs With Limitations in Quality or Access

Occupation ¹⁶	Educational Requirements ¹⁷	Years of Experience Required	Median Advertised Wage ¹⁸	Projected Growth 2021-2031 ¹⁹	Total Employment*	Transformation Cycle Classification
Wind Energy Development Manager	Bachelor's degree	2-5	\$124,650	6.0%	129 (1.3 million)*	Seed
Zoologist or Wildlife Biologist	Bachelor's degree	1-3	\$55,296	0.7%	17,100	Established
Chief Sustainability Officer	Bachelor's degree	4-8	\$106,300	-7.3%	7,762 (283,900)*	Established
Climate Change Policy Analyst	Bachelor's degree	1-5	\$57,200	4.7%	8,000	Scale
Sustainability Specialist	Bachelor's degree	2-5	\$81,960	5.0%	3,094 (1.1 million)*	Growth
Forest or Conservation Technician	Associate degree	1-4	\$37,554	-2.0%	32,700	Established
Environmental Science Teacher, Postsecondary	Doctoral or professional degree	1-2	\$31,668	7.7%	7,100	Established

* These roles include the job-posting numbers specific to the role as well as general BLS employment levels, which are in parentheses. Given how the BLS creates crosswalks between occupations in O*Net and the Office of Management and Budget's 2018 Standard Occupational Classifications six-digit occupational codes, overall employment captures a much broader range of occupations, not just green jobs. We believe that the posting volume shows that the "green versions" of these occupations account for much smaller portions of the total employment numbers, and thus we shared posting volumes first for these roles.

Sources: Burning Glass Institute analysis of Lightcast job postings data, Bureau of Labor Statistics Occupational Employment and Wage Statistics, O*Net, and Office of Budget and Management 2018 Standard Occupational Classifications.

Without filtering for quality jobs across access, wages, and growth, many of the sample jobs in Table 3 would appear in the seed or scaling job stages; the distinction lies in evaluating the intersection of job quality and green jobs to identify how and where we can accelerate a just transition to a green economy. However, based on the idea that all jobs, spanning all industries, have the potential to be green, the Green Transformation Cycle surfaces new roles that are seeing a green transformation as they integrate more green skills.

In a future where all jobs contribute to a green economy, we acknowledge that jobs are not at risk of displacement if they are not yet considered deeply green. A just transition to a carbon-neutral future will be achieved when all jobs are quality green jobs, with strong measures of job quality, and through the intentional integration of green skills.

Ultimately, this means that we see both quality green jobs and quality jobs that are becoming greener—including roles across all industries that play an important part in creating a clean and healthy environment



How to Identify More Green Jobs Through the Green Transformation Cycle



Quality Green Jobs in the Seed Stage

Seed stage refers to jobs and skills that are in an early-adoption phase but show promise for significant economic growth and an increasingly positive trajectory for their demand and adoption. Our research indicates that green seed stage jobs include roles that are deeply associated with new energy production fields such as nuclear fusion or tidal energy. Related roles include fuel cell engineer, tidal energy project manager, and hydrogen commissioning technician. In other words, this category will look traditionally green but can also include broader and more general occupations like engineer, project manager, or heavy machinery technician, respectively. We were able to capture these new, expanded seed stage roles through an analysis of skill content that was then mapped to new and emerging job roles, rather than through the formation of new occupations. Given the often very small scale of these new and emerging opportunities, skills analysis is often the most accurate way to identify seed stage developments.

In Table 4, we showcase examples of seed stage jobs and associated skills. While seed stage jobs representing new specializations in areas like nuclear fusion and tidal energy are very limited for now and are mainly concentrated in research and development firms, their associated skills are ripe for transferability and applicability to other, more generalized occupations that are beginning to rely on green skills and knowledge. We do not include projected growth or quantify what percentage of jobs will exist in this stage as skill adoption, and therefore the expansion of green job opportunities within this stage is nascent and there is not enough data to quantify how adoption will trend.

TABLE 4

Sample List of Seed Stage Jobs

Occupation ²⁰	Educational Requirements ²¹	Green Skills	Type of Skill Integration	Median Advertised Wage ²²
Tidal Energy Project Manager	Bachelor's degree	<ul style="list-style-type: none"> • Tidal energy • Environmental science • Environmental compliance 	Additive	\$62,300
Hydrogen Commissioning/ Liquification Technician (Mobile Heavy Equipment Mechanic)	High school diploma	<ul style="list-style-type: none"> • Hydrogen liquification 	Additive	\$53,040*
Wind Turbine Service Technician	High school diploma	<ul style="list-style-type: none"> • Wind turbines or hydraulics 	Additive	\$55,120

*Posted salary is for the occupation Mobile Heavy Equipment Mechanic overall. As a seed stage green role with 192 postings from 2018 to 2022, there is insufficient advertised salary data. Similarly projected growth from 2021-2031 is for the whole occupation from the BLS **Occupational Outlook Handbook**. Sources: *Burning Glass Institute analysis of Lightcast job postings data set*. Educational Requirements come from the BLS *Occupational Outlook Handbook*.

Given that many seed stage jobs are experiencing transformation due to additive skills, workers in these jobs could potentially develop transferable knowledge and skills, in areas such as environmental compliance, that could also be applicable in jobs in the scale or established stages. Additionally, workers in these roles will build more broadly applicable professional skills, such as project management and heavy machinery operation, that could transfer to different industries. For example, a tidal energy project manager could transfer their project management, reporting, and data analysis and visualization skills to

another field that is more prominent in clean energy, such as solar development or electric car production, among many others, and perform similar work while maintaining some tidal energy subject-matter expertise as that field continues to grow. In terms of the specialized skills these roles build, such as hydrogen liquification or hydraulics, it is important to note that their transferability is deeply dependent on other industries having a need for them. So even if the hydrogen sector does not expand at the expected pace, the skills that a hydrogen commissioning technician needs may show up in roles across manufacturing or construction.

Promoting Seed Stage Opportunities

While seed stage jobs and skills largely represent opportunities yet to come, it is still important to keep them in mind when considering the emerging green innovations that will shape our economy. They present the opportunity to be intentional about fostering racial and gender equity before job growth is cemented. Trends in seed stage roles also point to opportunities for education and training providers to proactively develop new strategic frameworks and skill-development programs, with the understanding that some roles will ultimately experience major employment growth in the green economy.

Looking more deeply at these seed occupations presents a stark reminder that many of them fall short when it comes to achieving parity in gender and racial representation. For example, nearly 67% of wind turbine service technicians are white, and just under 6% are women.²³ Similarly, energy product managers, which represent a broad range of occupations that will likely continue to add green skills, are also predominantly white and male; only 6% are Black.²⁴

Taken together, this raises a question: As energy project managers continue to gain specialized green skills, which populations of incumbent workers will be most likely to acquire this knowledge and, in turn,

have access to new and emerging roles? Further, as occupations rapidly evolve, the lack of racial and gender representation will remain stagnant over time without strong interventions from policymakers, employers, and education and career pathway programs that can better support expanded and diverse talent pipelines. Fostering long-term labor market equity will require intentionality on the part of training and upskilling programs to pull workers of color and women of all racial backgrounds into these professions. The risk of neglecting accessibility in job access will only further exacerbate existing racial and gender wage and wealth gaps.

While we wait for seed stage jobs to grow in investment and job availability, we expect that the core job skills found in such roles will be transferable to existing and well-established roles across related clusters of industries and sectors, and that the addition of seed green skills will be the major differentiator for access into newly emerging roles. This could involve building training and skilling programs that teach transferable skills, like project management, that could later incorporate green-specific skills to help workers become “seed job ready.” This represents a proactive approach to designing education and training models that are agile and ready for the future of work in a low-carbon, sustainable economy.



Quality Green Jobs in the Scale Stage

The scale stage comprises jobs or skills that have shown early and significant growth: Workers are increasingly gaining such skills, and employer demand for them is growing exponentially across job tasks and industry needs. As a result, jobs and skills in the scale stage have reached a point where they are on track to maintain steady growth. Examples of green jobs in the scale stage, such as solar panel installer and sales and wind turbine maintenance technician, are not at all surprising. Other jobs that are quickly incorporating green skills and showing similar growth trajectories include quality control analyst, machinery maintenance worker, and computer user support specialist.

Scale stage jobs and their associated green skills are critical for a just transition. Green skills, such as wastewater management and structural systems installation, will likely continue to expand and become more commonplace across sectors and industries, in roles that aren't typically viewed as green or in a green sector. Many of the scale stage jobs presented do not appear to be green at the surface level or based on the occupation—but, because of their changing skill content, they are a critical channel for the uptake and execution of green job functions and green skill development.

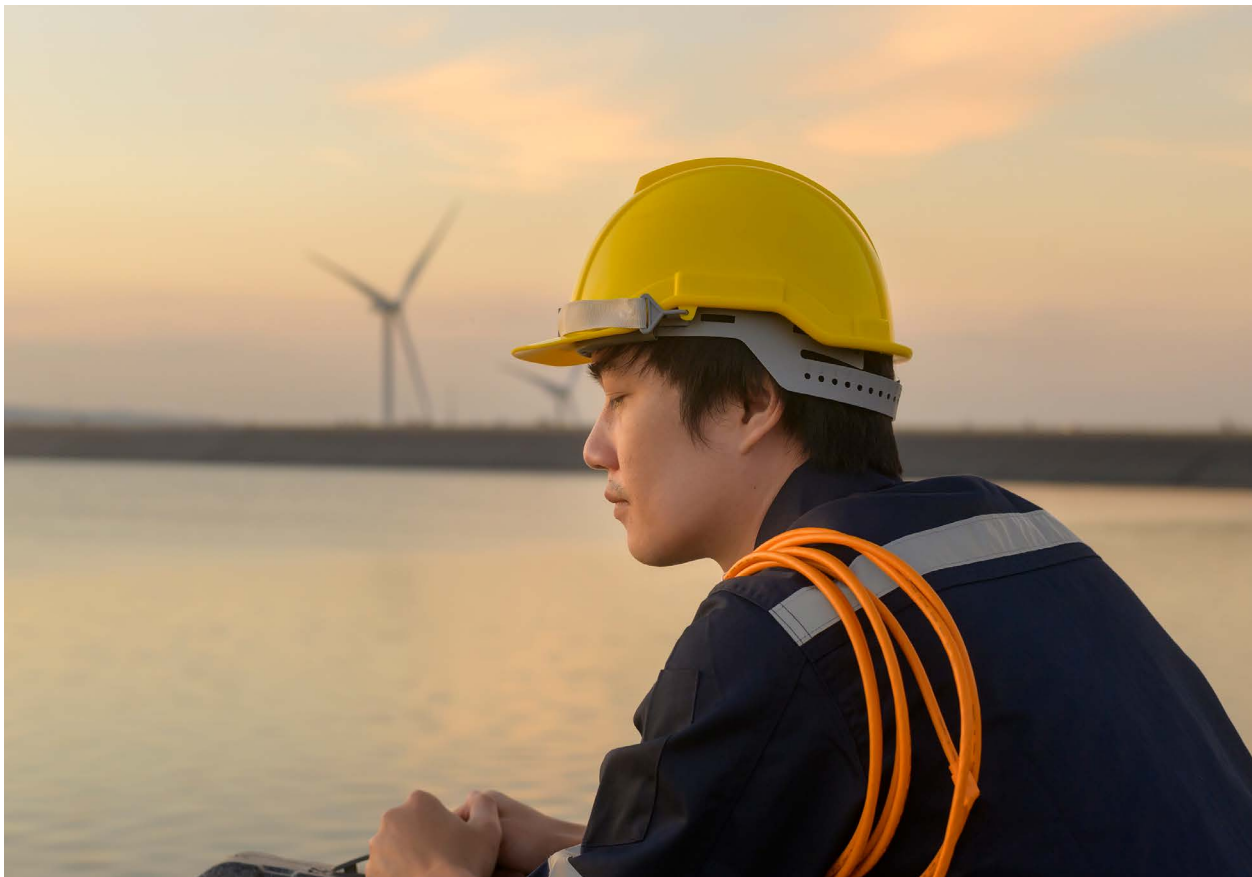


TABLE 5

Sample List of Scale Stage Green Jobs

Occupation ²⁵	Educational Requirements ²⁶	Sample Green Skills	% Growth in Skills Demand 2018-2022	Type of Skill Integration	Median Advertised Wage ²⁷	% Projected Growth 2021-2031 ²⁸	Total Employment
Network and Computer Systems Administrator	Bachelor's degree	Energy management	356%	Additive	\$77,970	3.4%	333,200
		Energy conservation	257%				
		Building environmental automation systems	76%				
Computer Network Support Specialist	Associate's degree	High-voltage and power electronics	225%	Additive	\$45,760	6.2%	185,500
		Environmental health and safety	200%				
		Electric utility and electric power transmission	61%				
Maintenance Worker, Machinery	High school diploma	Power plant operations	288%	Blended	\$48,900	7.8%	58,500
		Building environmental automation systems	158%				
		Wastewater management	113%				
Solar Sales Representative or Assessor**	Bachelor's degree	Electric vehicles	733%	Additive	\$112,500	5.1%	15,250 (280,700)+
		Solar consulting	430%				
Quality Control Analyst	Associate's degree	Greenhouse gas reduction and measurement	201%	Additive	\$49,030	6.6%	72,700
		Environmental resource management	144%				
		Environmental quality and air quality	80%				
Solar Photovoltaic Installer**	High school diploma	High-voltage commissioning	640%	Blended	\$45,760	27.2%	17,100
		Structural systems installation	626%				
		Solar energy systems	326%				

*Projected Growth and Total Employment come from the BLS **Occupational Outlook Handbook** and crosswalks to the broader Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products occupational codes rather than the O*Net code for Solar Sales Representatives and Assessors.

**These represent roles with a high overall green skills content mix and are among the top 10 greenest roles in our analysis.

+ This role includes the job-postings number specific to Solar Sales as well as the general BLS employment level for sales occupations, which is in parentheses. Given how the BLS creates crosswalks between occupations in O*Net and the Office of Management and Budget's 2018 Standard Occupational Classifications six-digit occupational codes, overall employment captures a much broader range of occupations, not just green jobs. We believe that the posting volume shows that the "green versions" of these occupations account for much smaller portions of the total employment numbers, and thus we shared posting volumes first for these roles. Sources: *Burning Glass Institute analysis of Lightcast job postings data, Bureau of Labor Statistics Occupational Employment and Wage Statistics, O*Net, and Office of Budget and Management 2018 Standard Occupational Classifications.*

These growing skills and job transformations are far from fully realizing their overall potential for the new green economy. Table 5 presents a sampling of scale stage jobs, including roles that are traditionally green, such as solar sales representative, as well as one that might otherwise be construed as nongreen, like computer network support specialist or network systems administrator. In these instances, growing and scaling green knowledge and skills like energy consumption or electric utility are no longer specializations relevant only in traditionally green sector jobs and instead appear across roles that are in other sectors, like manufacturing and IT.

Given that scaling jobs are on the verge of broad growth, ensuring that workers have access to such roles, as well as opportunities to gain the green skills that will allow them to maintain stable employment, is vital. For example, demand for skills in areas like environmental health and safety is increasing for roles like computer network support specialist. Given that 72% of all network support specialists are white and 76% are male, making such opportunities available to underrepresented workers is critical to closing equity gaps. The same trend is seen among solar sales representatives: The overall sales field, as defined by the BLS Occupational Outlook Handbook,

is 70% male and 88% white. While it is difficult to identify similar trends among seed stage green roles, such trends are seen in roles like project manager and engineer—which comprise an outsize proportion of workers who are white and male. Equipping diverse workers with potentially high-value specialized green skills to enable them to break into these fields could help address inequities in job access and representation. If these specialized skills can be acquired across populations and applied within subsectors of a wider range of occupations, that can lead to more diverse representation across various fields.



Notably, without intervention, innumerable scale stage jobs could evolve without built-in access or on-ramps for currently underrepresented workers. That is, those who could find stability in these roles in the future as they become more green are positioned to face the greatest barriers to entry and advancement. Scale stage jobs are growing and integrating new, specialized technical skill sets, but ensuring that workers can be effectively well positioned to advance as they build specialized technical skills requires intentional workforce development and intervention. These roles are driven by green skills that drive green product development and, as they scale up, create further opportunities for advancement, particularly among the communities most strongly impacted by climate change and least empowered to manage its adverse effects.²⁹

Planning for Scale Stage Realities

Unlike seed stage jobs, scale stage jobs represent existing roles in industries that are growing and expanding. In areas like wind and solar energy, there is little doubt that as adoption of these energy technologies continues, job opportunities will grow. Industry leaders should pay heed to changes in jobs in this category and proactively embrace these trends through upskilling and reskilling internally while also exploring how job tasks and roles will transform with these new areas of specialized knowledge. Government leaders and policymakers embracing more sustainable processes will need to partner with workforce developers to ensure that individuals are ready with the skills needed to act on these decisions.

Further, with new roles and career options growing in unpredictable ways, we believe it is important to focus on creating new opportunities for workers' economic mobility through intentional interventions. For example, durable green skills and knowledge could be incorporated into curricula and career and technical education programs for K-12 students, and into flexible work-based learning and coordinated certification and upskilling efforts for incumbent employees.

Quality Training Programs Expand Entry Into the Green Economy

As green and greening industries continue to reckon with diversity, equity, and inclusion, specialized training programs offer hope for expanding representation across multiple facets of identity. Athena Valenzuela, an office administrator for a family-owned solar energy company, said she feels connected to the green economy through her job. “It’s nice when people ask about certain things going on and I have an answer,” she said. In her role, Valenzuela designs first-draft solar renderings for the sales team, among other responsibilities.

She found her way to a career in solar through the Renewable Energy Academy of Learning (REAL) in California. This skills-focused workforce training program includes project-based learning, work-based learning, mentorship, and other supports to train and advance workers in the clean energy field through placement in either college or the workforce. Valenzuela entered the workforce right after high school, and her employer, Hot Purple Energy, has continued to invest in her by sponsoring training in relevant college courses.

“Solar, in general, is pretty unique,” Valenzuela said, noting that she feels she would not have necessarily found her way to such a job without REAL. “My grandma is always telling me, ‘I wish I had that opportunity when I was in school.’ It’s kind of nice to hear that. And I would say—for kids—just don’t be scared to put yourself out there and try these academies, because they do have benefits.” Investment in the type of accessible and early-career training that Valenzuela received could be an important lever for further workforce transformation.³⁰





Quality Green Jobs in the Established Stage

Established green jobs are ones that already largely rely on green skills and are supporting the shift to a low-carbon economy. While these jobs transform and embed new skills, it is important to recognize that the exponential growth in green skills seen in scaling jobs has already occurred in the established stage. While growth in green skills and overall demand may appear to be slower for jobs in this category compared with scaling jobs, these are stable green jobs that now face the normal cycles of growth and decline that most jobs in the broader labor market experience.

There is a wide range of occupations in the established stage, from frontline roles, like forest conservation technician and energy auditor, to executive-level roles, like chief sustainability officer. Because our approach to exploring the transformation and codification of all jobs as green takes quality and access into consideration, some perhaps unexpected roles came to light in the established stage, such as transportation manager and electrician, as shown in Table 6. Electricians are responsible for much of the installation of energy technologies that support clean energy distribution and energy efficiency, such as systems that power electric cars and manage battery usage. To stay eligible for these types of jobs, they must continue to grow their green knowledge in these areas. A parallel example is the role that transportation and distribution managers play in advancing a green economy. The skills needed for these roles have shifted significantly toward a strong focus on route efficiency, speed, and broadly sustainable and resilient transportation.

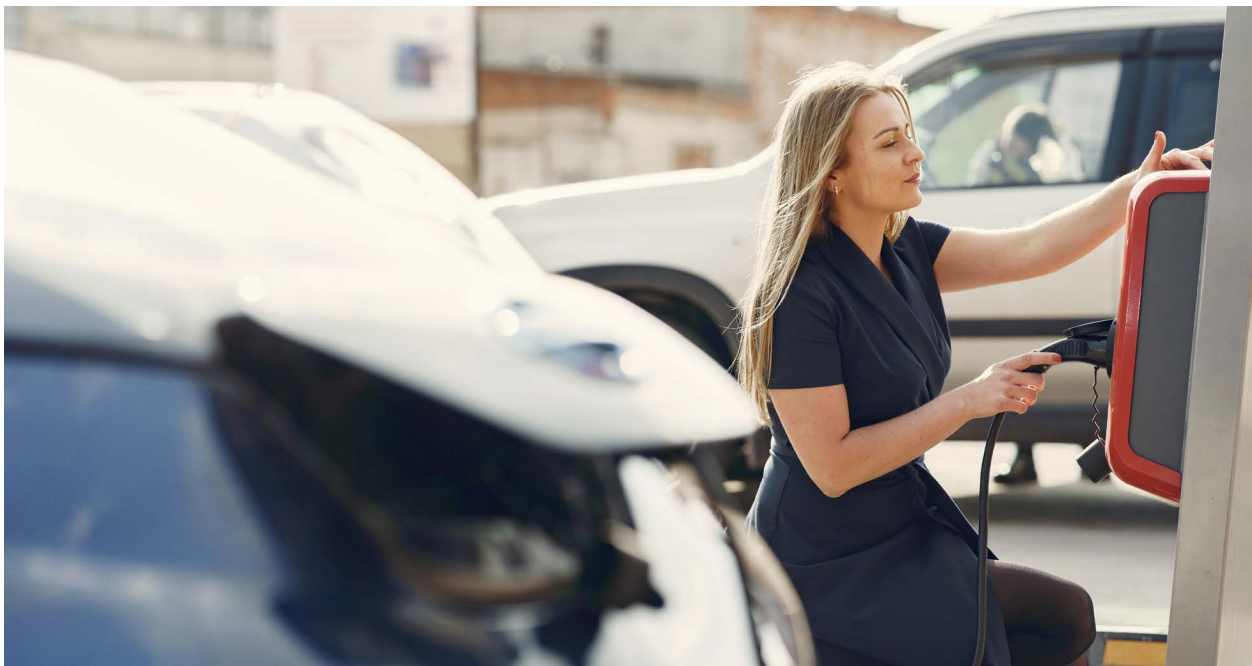


TABLE 6

Sample List of Established Stage Green Jobs

Occupation ³¹	Educational Requirements ³²	Sample Green Skills	% Growth in Skills Demand 2018-2022	Type of Skill Integration	Median Advertised Wage ³³	% Projected Growth 2021-2031 ³⁴	Total Employment
Electrician	High school diploma	Photovoltaics	484%	Blended	\$53,040	7.1%	711,200
		Solar panel installation	377%				
		Recycling	50%				
Environmental Science and Protection Technician	Associate's degree	Environmental data management	627%	Blended	\$47,370	5.9%	35,500
		Environmental remediation	511%				
		Technical/environmental reporting	290%				
Transportation, Storage and Distribution Manager	Bachelor's degree	Environmental health	640%	Job-changing	\$100,000	8.4%	150,700
		Stormwater management	309%				
		Sustainability initiatives	308%				
		Environmental monitoring	200%				
Transportation Vehicle, Equipment and Systems Inspector	High school diploma	Solar systems	6150%	Additive	\$79,700	1.8%	24,900
		Solar systems installation	1885%				
		Erosion control	760%				

*Projected Growth and Total Employment come from the BLS **Occupational Outlook Handbook** and crosswalks to the broader Sales Representatives, Wholesale and Manufacturing, Technical and Scientific Products occupational codes rather than the O*Net code for Solar Sales Representatives and Assessors.

**These represent roles with a high overall green skills content mix and are among the top 10 greenest roles in our analysis.

+ This role includes the job-postings number specific to Solar Sales as well as the general BLS employment level for sales occupations, which is in parentheses. Given how the BLS creates crosswalks between occupations in O*Net and the Office of Management and Budget's 2018 Standard Occupational Classifications six-digit occupational codes, overall employment captures a much broader range of occupations, not just green jobs. We believe that the posting volume shows that the "green versions" of these occupations account for much smaller portions of the total employment numbers, and thus we shared posting volumes first for these roles. Sources: *Burning Glass Institute analysis of Lightcast job postings data, Bureau of Labor Statistics Occupational Employment and Wage Statistics, O*Net, and Office of Budget and Management 2018 Standard Occupational Classifications.*

Some established occupations are incorporating subsets of new green skills and therefore present an opportunity to reach a wide array of workers through skills-based training, given the occupation's established presence in the U.S. economy. For example, transportation-related fields have offered pathways into multiple job and career opportunities. After training and working as an electric vehicle battery technician, "I never imagined doing something this techy," said Jeffrey Cleveland. "I would love to continue this type of work and stay in this field. That's what I want to do. It's the future."³⁵



Established roles represent key opportunities to develop skills-based training for new and incumbent workers on a relatively large scale, meaning we can plan for and develop reliable workforce development strategies and training programs to better support expanded entry into these jobs.

Centering Job Quality and Access for Established Green Jobs

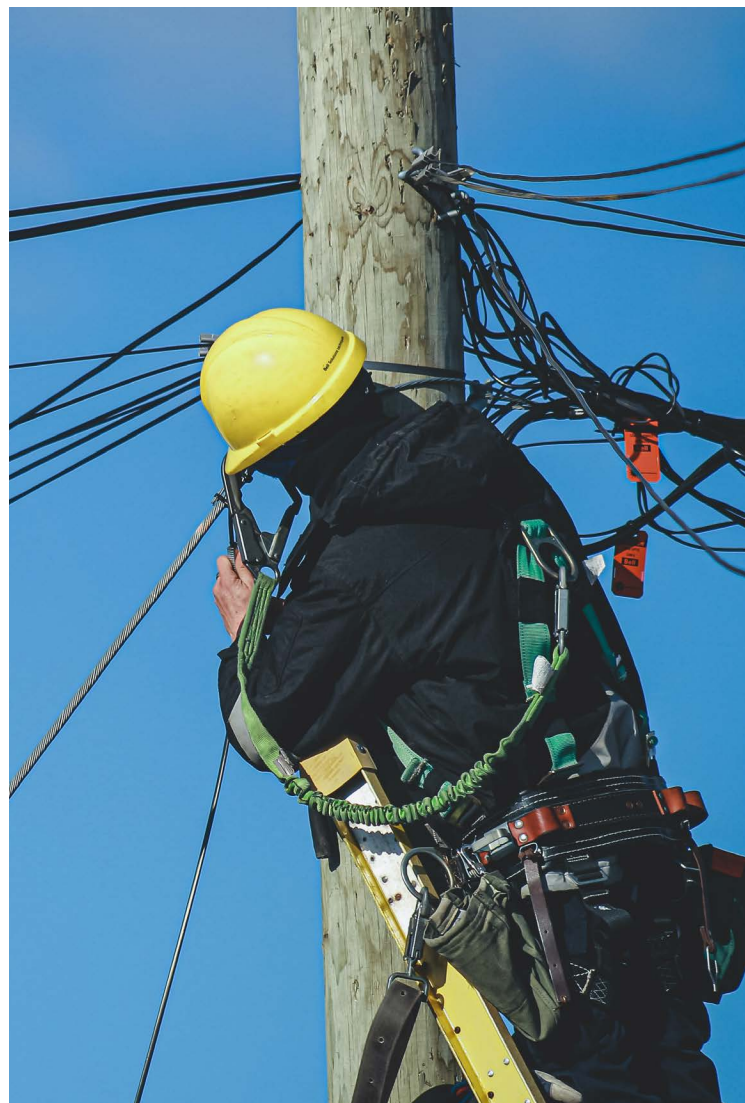
While many established green jobs align to deeply green positions like chief sustainability officer and others presented in Table 3, we believe that it is critical to take a broader view of the roles that are contributing to a changing and greening economy. The roles in Table 3 are often considered "core" to the green economy—but they aren't the only roles. Our broader, skills-based analysis helps to better capture how the economy is greening, the economic opportunities emerging from a greening economy, and the skills that will help to drive that transformation. It will be important for workforce boards and industry leaders to intentionally incorporate green skills into work-based learning and training, as well as existing K-12 curricula, to support people's job transitions and careers earlier in their educational journeys.

Further, many of these roles can embrace multiple pathways, such as apprenticeships, earn-and-learn models, and sector-based internships, which would allow individuals to enter these fields more easily and gain specialized knowledge as low-carbon transformations continue. Without intentional training to match the needs of workers in roles that require new blends of skills, it is unlikely that established roles will become more equitable and representative of the population overall.

But it is important that the workforce becomes more representative through new workers entering these jobs. For example, 82.5% of electricians and 88.3% of transportation managers are white. Less than 2% of electricians are women. These roles continue to be predominantly filled by white and male workers, but workforce training programs can use established approaches to better inform their programming and prepare women, people of color, and individuals with disabilities for green jobs.

Many of the new green skills that workers of the future will need for these roles will enable our transition to new energy sources or our ability to efficiently manage logistics and new modes of transportation. Such skills are, in fact, often available for workers, but through on-

the-job training programs. Unfortunately, because these jobs do not currently reflect the demographics of the broader population, workers from systemically underrepresented populations, who are already underemployed in the field, will not have to access such learning opportunities. This could widen the existing employment gap in these roles and make future roles even harder to access.





Jobs at Risk of Disruption or Displacement

Jobs we have identified as at risk are experiencing inverse trends in green skill adoption—that is, these jobs are exceptionally vulnerable to displacement or disruption in the emerging green economy. In many cases, skills that are flagged as at risk are associated with work that is carbon intensive or environmentally harmful and will likely decline as new, clean energy sources are developed, incentivized, and implemented.

In this case, our framework allows us to more intentionally identify early-warning signals of declining skills or jobs to allow for interventions that can protect workers from the vulnerability of job loss or displacement, particularly since green innovations are still emerging. Often, these roles are fully transitioning to new functions or seeing significant change or disruption due to broader economic trends that are relevant in the low-carbon economy, but these changes can also write individuals out of their roles if they are not properly trained or educated to embrace new responsibilities.

For example, jobs in sectors that are not climate friendly, such as oil and gas service unit operator, pump operator, and power plant operator, are increasingly incorporating skills, including building environmental automation systems, load management, system resilience, and advanced asset management, to make power production facilities operate more efficiently and sustainably. In other words, they are evolving by incorporating green skills in order to be more stable through the economic transformation. Workers who remain in these roles must learn and continue to develop competence with green skills to remain relevant and avoid displacement due to a lack of knowledge. Based on the content knowledge required for these jobs, we expect that they will experience significant transformation and may eventually decline, though the BLS sees them as growing in the overall labor market for the next 10 years. Roles like the ones identified in Table 7, which are highly concentrated in the energy production and mining sectors, are examples of deeply disrupted roles that will require workers to increase their knowledge and skills to be qualified for jobs in the green economy.

TABLE 7

Sample List of Jobs At Risk for Disruption or Displacement

Occupation ³⁶	Educational Requirements ³⁷	Sample Green Skills	% Growth in Skills Demand 2018-2022	Type of Skill Integration	Median Advertised Wage ³⁸	% Projected Growth 2021-2031 ³⁹	Total Employment
Power Distribution and Dispatcher	High school diploma	Continuous emissions monitoring systems	680%	Job-changing	\$47,840	-6.6%	9,700
		Chemistry	192%				
		Plant efficiency	114%				
Service Unit Operator, Oil and Gas	On-the-job training	Reverse osmosis	200%	Additive	\$41,600	17.5%	35,700
Pump Operator	High school diploma	Managing water resources	300%	Additive	\$42,485	11.4%	11,000
		Environmental compliance	134%				
Heavy and Tractor Trailer Truck Driver	Postsecondary credential	Environmental compliance	554%	Additive	\$48,310	4.3%	2.1 million
		Recycling	348%				
Chemical Equipment Operator	High school diploma	Environmental compliance	406%	Additive	\$48,090	-5%	110,300
		Environmental policy	160%				

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**These represent roles with a high overall green skills content mix and are among the top 10 greenest roles in our analysis.

+ This role includes the job-postings number specific to Solar Sales as well as the general BLS employment level for sales occupations, which is in parentheses. Given how the BLS creates crosswalks between occupations in O*Net and the Office of Management and Budget's 2018 Standard Occupational Classifications six-digit occupational codes, overall employment captures a much broader range of occupations, not just green jobs. We believe that the posting volume shows that the "green versions" of these occupations account for much smaller portions of the total employment numbers, and thus we shared posting volumes first for these roles. Sources: *Burning Glass Institute analysis of Lightcast job postings data, Bureau of Labor Statistics Occupational Employment and Wage Statistics, O*Net, and Office of Budget and Management 2018 Standard Occupational Classifications.*

In the period from 2018 to 2022, based on BGI's analysis of Lightcast job postings data, over 3.2 million job postings in the United States called for traditionally nongreen skills directly associated with the oil and gas industry, a sector we expect will undergo major transformations to remain relevant in a low-carbon economy. Essentially, industries such as oil and gas, agriculture, manufacturing, and mining will need to embrace transformations that support greening, and if even a small portion of these jobs are affected, major efforts to prepare incumbent workers will be vital to ensure their job security and stability. Additionally, industrial and occupational decline is often a long-wave economic trend not captured by the 10-year BLS projections. For example, while jobs for heavy-truck drivers are projected to grow somewhat, the total volume of job postings for the role declined during our study period.

Responding to Disruption and Decline

Future work from JFF through the CREST initiative will further explore the dynamics of the risk of displacement and loss for roles that cannot be sustained in a greener economy and how to navigate their evolution and reformulation through this transformation. Meanwhile, those jobs that may evolve to resist disruption need

to be planned for. Managing the transition involves aligning skills to new job demands for those who continue in at-risk roles—largely helping workers adopt new skills that can help them be more resilient and more effectively avoid job displacement in the climate transformation. Additionally, there is a promising opportunity to intentionally transition such jobs to be resilient in a low-carbon economy while ensuring that incumbent workers can maintain their roles during the transition.

It is important to highlight the opportunity to drive equity through the proper management of transitioning industries, occupations, and skill sets. Our research suggests that workers from systemically underserved and underrepresented populations are more likely to be in occupations that are in transition and at a greater risk of being disrupted. Based on Lightcast data analysis by BGI, in the examples above—power distribution and dispatcher, service unit operator, and pump operator—Hispanic and male workers are particularly at risk: An estimated 96% of workers in those roles are male and 23.3 percent Hispanic, even though the overall labor force is 65.5% male and 18% Hispanic. Careful, deliberate efforts by educators and the workforce development system to link workers—especially workers who have faced barriers to economic mobility—to new and

emerging opportunities will be critical, as well as helping them connect to programs and courses that build skills for these roles and beyond.

Our research suggests that many jobs that are at risk of long-term decline and disruption provide accessible, well-paying

opportunities for workers who lack a four-year college degree. Ensuring that future established and scaling jobs similarly meet these standards will require the close attention of the workforce development field.



An overhead photograph of a meeting. Several people are seated around a dark wooden table. In the top left, a man in a yellow jacket and glasses is looking down. In the top right, a bald man in a white shirt and glasses is looking down. In the bottom center, a woman with dark hair in a brown top is looking down. On the table, there is a laptop, a smartphone, a notebook, a pen, and a small potted plant. The background is a light-colored wall.

Ensuring That All Green Jobs Are Quality Jobs

The importance of integrating strong job-quality standards alongside the green skills, as well as their impacts on jobs in the green economy, cannot be emphasized enough. Today, nearly one-third of the U.S. labor force earns less than \$31,200 annually. Within that group, both women and people of color are overrepresented. Some 47% of Black workers and 46% of Latinx workers fall below that income level, compared with 26% of white workers.⁴⁰ Moreover, as research has shown, wages are only one marker of a quality job.

JFF has developed its own comprehensive definition that embraces the idea that wages alone are not a sufficient indicator of quality: “A quality job provides not just a living wage and benefits but also stability, flexibility, autonomy, and equitable economic advancement.” [JFF’s Quality Jobs Framework](#) applies a four-pronged approach to defining job quality through advancement, compensation, agency and culture, and job structure. We recommend that employers, workforce development boards and practitioners, policymakers, postsecondary institutions, secondary schools, and community-based organizations consider and adopt this framework.⁴¹

Advancement

Job quality must take into account the ways in which workers are able to train for, access, and advance to and through stable jobs. This will require employers, secondary and postsecondary schools, community-based organizations, local and state workforce development boards, and policymakers to engage in cross-sector

efforts to clarify and expand access to green job pathways for all. Integrated solutions can take many different forms, such as pre-apprenticeships and Registered Apprenticeships, work-based learning models in high school and college, and community-based training programs offering industry-recognized credentials.

An Entrepreneur’s Vision for Equitable, Accessible Training

Mark Hall, founder of Revalue.io, “a minority-owned, full-service energy efficiency project developer,” is helping to prepare communities for the transition to clean energy through local, customized energy and health assessments and building improvements. As an employer, his work focuses on helping local contractors of color enter the clean energy industry by hiring them for energy-efficient building renovation projects and connecting them to the training they need to advance in the field.

When asked what motivated him to start Revalue.io, Hall said, “I wanted to have more control over who gets hired, how it gets put together, and wanted to pursue something that would allow more autonomy to make change and hire from disadvantaged communities.” Throughout his own career, he has seen that contractors of color are often overlooked for jobs and that even pathways into union labor jobs are often fraught with logistical barriers, as well as nepotism and racism.

Access to high-quality skills-based training is vital for the green economy but is not always attainable to or representative of all communities. “Practical knowledge is best for industry skills and immediate knowledge gain. Accessibility in training programs needs to be emphasized—we need more of it,” Hall said. When asked how he would accelerate the transformation of the green economy, Hall said he would establish energy efficiency and electrification classes and on-the-job training hubs in every county to begin to meet future demand more equitably.⁴²

The jobs and skills data highlighted throughout this report may serve as useful references in efforts to build green job pathways. Education and workforce systems should strive to build specialized training—for skilled technical jobs to early and midlevel professional positions—that acknowledges and incorporates new green skills while working with employers and their incumbent workers to articulate and identify opportunities for work-based upskilling and reskilling. Career pathways should also support workers who are in jobs that may be at risk for decline or significant transformation as the green economy continues to evolve and dictates new skills, technologies, and job duties. While significant divestment from fossil fuels is not imminent, the seed stage jobs described in this report, such as those in nuclear fusion and tidal energy, could serve as useful building blocks for the kinds of green career pathway and skills training we will need in the decades to come.

Quality established and scaling jobs can also gain more momentum in the workforce if more training and postsecondary credential or degree programs are built out with not only these roles in mind but with committed employers eager to hire their graduates. Furthermore, prioritizing advancement is crucial so that once someone begins a green job, they see a future of upward

mobility within their industry that can continue to be augmented through employer-invested skills training.

Compensation

A living wage is a vital component of a quality job, green or not. Some of the green jobs listed in Table 3, such as aircraft service attendant and forest conservation technician, still have progress to make in terms of the compensation offered. Workers in these roles are learning new and emerging green skills to keep up with what is needed to be successful as the economy greens and climate impacts evolve. Both employers and policymakers also have a responsibility to strengthen compensation and benefits that reflect the quality of work these and other green workers provide.



Beyond earning a living wage, workers in quality green jobs should have access to quality benefits that allow them to continue to invest in their future and to maintain their own and their family's health, with access paid leave. For green jobs specifically, employers and policymakers might also consider the ways in which employees' access to the systems and products they are developing can be expanded. For example, amid efforts to encourage people to purchase electric vehicles, not all manufacturing companies offer benefits that make it easier for the technicians they employ to purchase such vehicles.

Electric vehicle materials worker Armando Acosta reflected, "It's easy to say that we are green, but not everyone realizes how expensive it is to turn the world green. People who own these companies need to remember to give back to their people, not just with talk about it for others."⁴³ In essence, compensation for quality green jobs must go beyond just a living wage and address the ways in which workers can be supported in the long term and access the very economy they are working to build.

Job Structure

Many green jobs in squarely green industries, such as clean energy, require intensive manual labor—from supporting the installation of solar panels and the assembly of electric vehicles to the construction of wind turbines. The ways in which green jobs are structured to promote physical safety, stability, and predictability when it comes to fair and transparent scheduling is an imperative component of ensuring job quality across all green jobs. Acosta highlighted the importance of safety and a specialized training process. "There are reasons why there are protocols and why certain parts are important," he said, citing the dangers of malfunction and even fires. "Safety is a big thing that people need to be taught more about when it comes to green industries, and people don't always realize it."⁴⁴

Workers in green jobs should also feel secure that their employer complies with anti-discrimination and anti-harassment laws. Employers and policymakers should continue to work toward implementing and investing in strong workplace laws related to workplace health and safety and ensure the equitable application of all such policies and practices.



Agency and Culture

The fourth aspect of JFF's Quality Jobs Framework is rooted in both worker agency and a job culture that allows workers to feel a strong sense of belonging. This includes the ability to exercise decision-making power, not only within their individual roles but also within the organizational culture. In a recent worker-led research study JFF conducted, a sense of ownership emerged as a critical component of job quality among the workers who were interviewed.⁴⁵ They defined ownership in psychological terms: feeling that they have agency over the direction of their work, experience tangible ownership and a legal claim to financial assets and have the power to make decisions or negotiate on pay and benefits.⁴⁶ Ownership can take many forms, including co-operative approaches

to leadership and stock options—something Acosta has benefited from and plans to gift to his grandchildren.⁴⁷

Internal organizational policy that promotes diversity, equity, inclusion, and accessibility (DEIA) is also a necessary first step in ensuring that workers have access to a culture that fosters these core values and ultimately works toward ensuring a sense of belonging for all. Given that women and people of color are persistently underrepresented in green jobs, companies should implement strong DEIA policies that, for example, consistently promote and invest in anti-bias hiring and training, in addition to carving out space for affinity groups so people can gather and share their thoughts and ideas about their experiences at work.

Recommendations: Moving Toward Quality Green Jobs

Knowing that jobs won't change unless our industries, practices, and policies do, below we offer a series of recommendations for workforce development practitioners (workforce development boards, community colleges, and community-based training programs), employers, and policymakers to consider as they continue to play a pivotal role in the development of the green economy. To begin this work, we recommend actions in three key areas:

1

Build and support inclusive, quality career pathways through cross-sector partnerships that amplify emerging green skills and experience for all people, from incumbent workers to new learners.

2

Expand employer job structures to include living wages and comprehensive benefits for all workers alongside strong internal workplace policies that aid in retaining local talent.

3

Design and enact green jobs legislation with population-specific strategies to serve all workers.

1

Build and support inclusive, quality career pathways through cross-sector partnerships that amplify emerging green skills and experience for all people, from incumbent workers to new learners.

Actions for multiple stakeholders include the following:

- Using the green transformation data shared in this report, as well as continually updated local labor market data, explore the ways in which seed, scale, and established green and skills can influence and shape your training programs to better prepare workers for the green economy.
- Where applicable, use scaling and established skills to shape career pathways for traditionally nongreen job paths to prepare workers for possible transitions into the green economy. Use job and skill data for at-risk roles to inform how your career pathways may shift to better support and prepare workers for a smooth career transition.
- Expand talent pipelines to build stronger relationships with local postsecondary and community-based training programs that are focused on scaling and established green skills.
- Promote decisions at the state and local levels to adopt sustainable practices while ensuring training services and support are in place to help workers navigate these changes.
- Intentionally and meaningfully carve out funding to prioritize equity-focused, population-specific strategies for reducing racial, gender, and disability gaps in seed, scale, and established green jobs, as well as funding to support career on-ramps for individuals who will need to eventually transition out of at-risk jobs.

2

Expand employer job structures to include living wages and comprehensive benefits for all workers alongside strong internal workplace policies that aid in retaining local talent.

Actions for employers and policymakers include the following:

- Prioritize salaries that reflect a living wage for your geographic area and include benefits that allow workers sick and personal paid leave as well as maternity or paternity care, for scaling and established green jobs.
- Expand policy and reporting requirements to enable stability and safety on the job through practices like transparent scheduling, detailed and transparent anti-discrimination policies, and detailed job hazard guidance and reporting measures.
- Enact laws or enforce existing ones that set strong standards for high-quality jobs, including clear measures on family-sustaining wages and benefits and incentives for employers to create jobs that meet such standards.

3

Design and enact green jobs legislation with population-specific strategies to serve all workers.

Actions for policymakers, advocates, and implementers include the following:

- Advance green jobs legislation that tangibly addresses regional variations in jobs and skills, with access to green skills training and career pathways evenly distributed across regions rather than hyperfocused only where the skills and infrastructure already exist. This could take the form of geographic incentives for employers, targeted support for postsecondary institutions, and inclusive regional economic development projects.
- Make use of policy to invest in testing viable workforce interventions across cities, industries, and sectors while also promoting job creation; provide work-based training models, apprenticeships, and other proven pathways to stable and reliable jobs for workers while allowing them to contribute to a low-carbon economy.
- Create incentives for businesses and innovations related to climate change and a just transition to the green economy that are led by those most directly affected by climate change, including women, Black and Indigenous communities, underserved communities, individuals with disabilities, and formerly incarcerated individuals.



Conclusion

The pursuit of a greener economy is both critical and inevitable. But a truly just transition will not happen on its own. Leaders and stakeholders representing workforce systems, education and training pathways, policymaking, community development, and more must prioritize economic activity that is interconnected with long-term environmental and social impacts. This will require removing the limitations around how we define and categorize green jobs and the transferable skills needed to build a climate-resilient future and workforce.

All jobs have the potential to become quality green jobs through the intentional integration of green skills, knowledge, and job-quality standards. Prioritizing job access and equity across communities will, in parallel, move us toward closing the racial and gender equity gaps that plague much of the current green movement. As our economy continues to respond to climate change, the Green Transformation Cycle framework can serve as a useful resource to prepare the U.S. workforce for a just transition to a strong, equitable, and accessible green economy for all.

Appendix A: Methodology

JFF and BGI partnered to strategize how best to identify and quantify the nature of the economic transformation as the United States transitions to a low-carbon economy. We relied on Lightcast tools, including the online job postings data set, alongside publicly available job trend data, employment and wages data from the BLS Occupational Outlook Handbook, and the Occupational Employment and Wage Statistics data set.

Identifying Skills for Analysis

To track the trajectory of green skills and the skills content of roles, we analyzed over 198 million job postings from 2018 to 2022 as collected in the Lightcast job postings data set. We used several approaches to identify new and emergent green skills and skills that, while transferable to nongreen roles, help drive green work.

To identify green skills, we started by reviewing broadly accepted and verified green skills—largely leaning on the literature on the green sector and definitions of the green economy from BLS and UNEP. We started with a list of terms from the fields that are captured in the BLS definition of green jobs—those associated with renewable energy production, energy efficiency, and environmental management.

We then used several machine learning and natural language processing approaches to identify the skills that are deeply connected to the “seed” green skills, to ensure that we had a robust list of green and nongreen skills that drive the green economy. We used several statistical approaches, including a measure of revealed comparative advantage and a method known as TFIDF (term frequency–inverse document frequency), that helped to normalize the occurrences of these skills in job postings to ensure that they are differentiating and critical skills for the roles and not just frequently occurring skills. This analysis created the set of skills that we consider green skills (those that are deeply associated with the green economy) but also skills that may not traditionally be considered green but are critical and occur much more frequently in green job postings (the nongreen skills that help drive the green economy). As with any analysis of this nature, some skills identified through these statistical approaches are more likely statistical artifacts. We left these in the model and instead used the broad set as a heuristic to better understand green transformation across the labor market.

Identifying Jobs for Analysis

After identifying the set of green skills, we used a similar approach to identify

the occupations that have the deepest concentrations of green skills; however, we pushed beyond that metric by looking at growth trajectories of green skills through the Green Transformation Cycle framework. In this paper, to identify some common measures of job quality, we screened roles across three data points:

- Measures of job accessibility: Is a job generally or commonly available and open to workers without a college degree? Is a job generally accessible with limited years of professional experience?
- Wage: Does the job pay approximately \$25 an hour or \$50,000 a year to suggest at least a living wage?
- Growth: Is the job expected to grow in the future?

While an imperfect measure, we believe these three screening questions helped us align identified green jobs to those that provide quality employment.

Certainly, other measures of quality can be incorporated into the identification and screening of employment opportunities.

Applying the Green Transformation Cycle

Classifying a role and skills into a specific stage of the Green Transformation Cycle involves a combination of several factors.

For skills, we primarily looked at whether the skill was new to the data set, the absolute number of postings or roles, and especially the growth trajectory of the skills. To measure growth trajectory, we assessed the shape of growth:

- Is it exponential growth? This is associated with seed stage and very early growth stages.
- Is it linear growth? This is associated with the scale stage of the Green Transformation Cycle.
- Is it nearly flat, with hiring and job posting levels suggesting that hiring is for replacement rather than growth? This suggests the role is in the established stage of our framework.
- Finally, is there a decline or negative trend? This suggests that there is a risk of displacement or disruption.

We mapped similar analysis onto jobs: Are they seeing green content as a significant portion of the role that has incorporated green skills or seen green skill growth? The pace of adoption of green skills allowed us to classify jobs as seed, scale, established, or at risk.

Top 20 Occupations With the Highest Green Skill Concentrations

Solar Sales Representatives and Assessor	Energy Auditor	Wind Energy Operations Manager	Range Manager	Zoologist or Wildlife Biologist
Park Naturalist	Reinforcing Iron and Rebar Worker	Farmer, Rancher, or Other Agricultural Manager	Chief Sustainability Officer	Cement Mason or Concrete Finisher
Aircraft Service Attendant	Glass Blower, Molder, Bender, or Finisher	Climate Change Policy Analyst	Bus Driver, School	Sustainability Specialist
Tire Repairer and Changer	Forest and Conservation Technician	Media and Communication Worker, All Others	Environmental Science Teacher, Postsecondary	Solar Energy Systems Engineer

Additional Examples of Established Stage Roles

Brownfields Redevelopment Specialist and Site Manager	Soil and Plant Scientist	Biofuel Technology and Product Development Manager	Transportation Vehicle, Equipment and Systems Inspector
Insulation Worker	Compliance Manager	Recycling and Reclamation Worker	Data Warehousing Specialist

Additional Examples of Scale Stage Roles

Wind Energy Development Manager	Solar Energy Systems Engineer	Hydroelectric Plant Technician
Project Management Specialist	Energy Auditor	

Additional Examples of At-Risk Roles			
Heavy and Tractor-Trailer Truck Driver	Continuous Mining Machine Operator	Power Plant Operator	Chemical Equipment Operator
Chemical Plant Operator	Excavating and Loading Machine Operator	Mining and Geological Engineer	

Appendix B: Common Definitions of Green Jobs

The BLS defines green jobs as “jobs in businesses that produce goods or provide services that benefit the environment or conserve natural resources” or “jobs in which workers’ duties involve making their establishment’s production processes more environmentally friendly or use fewer natural resources.”⁴⁸ This definition generally classifies green jobs into three main industries: renewable energy production, energy efficiency, and environmental management.

UNEP considers green jobs to be “jobs that work in agricultural, manufacturing, research and development, administration, and service activities that contribute substantially to preserving or restoring environmental quality.”⁴⁹ In contrast to the BLS definition, UNEP then goes a step further to emphasize that green jobs need to be “good jobs which offer adequate wages, safe working conditions, job security, reasonable career prospects, and worker rights.”⁵⁰

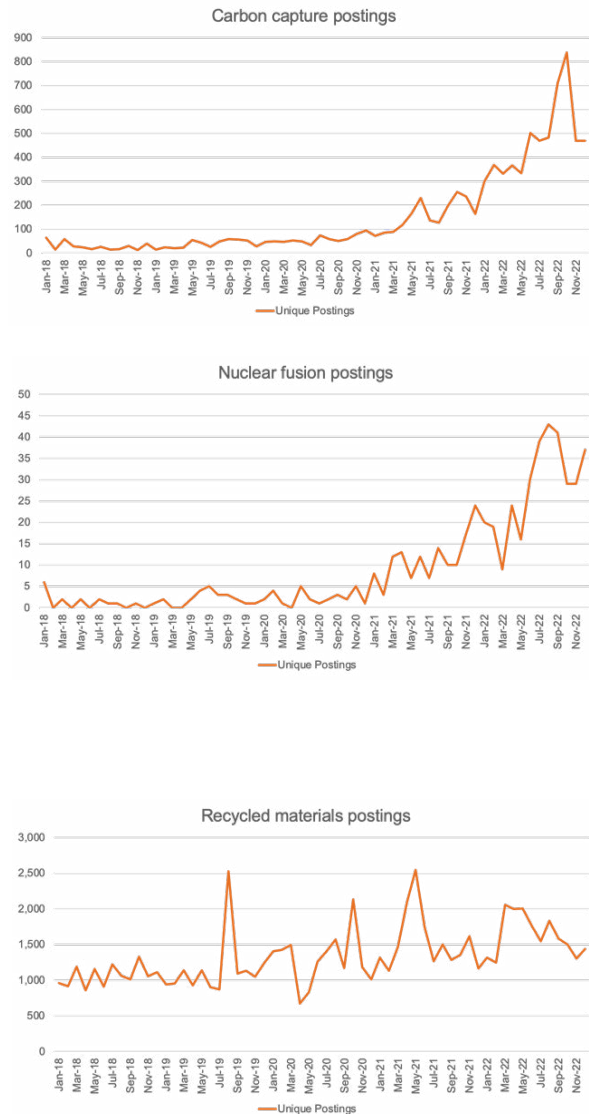
Appendix C: Skill Transformation

When assessing skill content across occupations to identify quality green jobs, several broad and important trends were clear. First, many jobs did not meet the common definitions of a green job and were not included in the BLS definition of green jobs—largely because the roles do not directly create a green product, nor do they directly engage in developing or greening a process at a firm or organization.

Yet our method of assessing the content continued to find that many occupations were undergoing often small changes but, in aggregate, at a major scale. Often, this manifested as a small subset of skills within a broader set of responsibilities and capabilities in an occupation; in these cases, we see it as additive. Other times, new skills showed up as broader sets of new functions within existing roles—creating new blends of roles. Finally, some roles saw significant shifts in skill sets. Many well-paying, highly accessible, and growing jobs were greening in small but profound ways.

Skills often show demand and adoption curves that are like the framework presented for the overall Green Transformation Cycle. Below, we share examples of two green skills—carbon capture and nuclear fusion—to illustrate how we review skill adoption in the transformation cycle. Both skills show curves demonstrating seed stage adoption and growth curves that demonstrate early exponential growth curves that are not yet sustained enough to suggest that they will become established skills.

Figure 3 displays the frequency of job postings requesting skills related to the processing and management of recycled materials—a skill we expect to see in the scale stage. While in some months the number of job postings citing this skill peaked or declined sharply, in a year-over-year analysis we found that demand is steady or slightly growing alongside general economic growth. Furthermore, this trend aligns with the broad adoption of recycling in the United States and with policies at the federal and local levels that have required a broader understanding of and reporting on environmental impacts and the execution of environmental impact studies.



Endnotes

1. Alejandra O'Connell-Domenech, "The Top 5 States With the Most 'Green' Jobs," The Hill, July 12, 2022, <https://thehill.com/changing-america/sustainability/environment/3556257-the-top-5-states-with-the-most-green-jobs>.
2. Jeff Ryder, "People of Color and Women Remain Underrepresented in Green Jobs," WorkingNation, February 24, 2021, <https://workingnation.com/people-of-color-and-women-remain-underrepresented-in-green-jobs>.
3. "Frequently Asked Questions on Just Transition," International Labour Organization, accessed May 16, 2023, https://www.ilo.org/global/topics/green-jobs/WCMS_824102/lang-en/index.htm.
4. Tameshia Bridges Mansfield, "Together We Can Help Employers Create Quality Jobs," Jobs for the Future, September 1, 2022, <https://www.jff.org/points-of-view/introducing-quality-jobs-framework>.
5. Fernanda Bárcia de Mattos, *Employment Research Brief: Green Growth, Just Transition, and Green Jobs: There's a Lot We Don't Know* (Geneva, Switzerland: International Labour Organization, 2018), https://www.ilo.org/wcmsp5/groups/public/-ed_emp/documents/publication/wcms_628605.pdf.
6. Global Green Skills Report 2022 (Sunnyvale, California: LinkedIn, February 2022), <https://economicgraph.linkedin.com/content/dam/me/economicgraph/en-us/global-green-skills-report/global-green-skills-report-pdf/li-green-economy-report-2022-annex.pdf>.
7. Lightcast 2023.1 data, analyzed by Burning Glass Institute.
8. Forced Labor and the Clean Energy Transition: Finding A Responsible Way Forward", Office to Monitor and Combat Trafficking in Persons, United States Department of State, July 2022, <https://www.state.gov/wp-content/uploads/2022/07/Forced-Labor-and-the-Clean-Energy-Transition-Finding-A-Responsible-Way-Forward.pdf>

9. Mark Muro, Adie Tomer, Ranjitha Shivaram, and Joseph Kane, *Advancing Inclusion Through Clean Energy Jobs* (Washington, DC: The Brookings Institution, April 2019), https://www.brookings.edu/wp-content/uploads/2019/04/2019.04_metro_Clean-Energy-Jobs_Report_Muro-Tomer-Shivaran-Kane_updated.pdf.
10. Karin Kimbrough, “These Are the Sectors Where Green Jobs Are Growing in Demand,” World Economic Forum, September 23, 2021, <https://www.weforum.org/agenda/2021/09/sectors-where-green-jobs-are-growing-in-demand>.
11. Interview with Rafael Aguilera, March 24, 2023.
12. We borrowed from and adopted ideas from product lifecycle theory to develop the Green Transformation Cycle. Like new innovations, green skills and technologies are being developed and introduced constantly—following trends similar to those presented in product lifecycle theory. It has been adapted to incorporate a skills-based perspective and, overall, our perspective on the transformation of green jobs for a just transition to a green economy. See Carol M. Kopp, “Product Life Cycle Explained: Stage and Examples,” Investopedia, March 16, 2023, <https://www.investopedia.com/terms/p/product-life-cycle.asp>.
13. “Green Job Creation and Regional Economic Opportunities at the State Level,” Renewable & Appropriate Energy Laboratory, UC Berkeley, accessed May 21, 2023, <https://rael.berkeley.edu/project/green-jobs>.
14. Daniel Edelman, “Who Will Get All the New Green Jobs?” Next100, November 9, 2021, <https://thenext100.org/greenjobs>.
15. Adapted and defined based on MIT’s calculated national wage: “\$104,077.70 per year in 2022, before taxes for a family of four (two working adults, two children), compared to \$24.16, or \$100,498.60 in 2021.” Note that this is a general wage estimate with variability based on regional nuance and needs. Amy K. Glasmeier, “New Data Posted: 2023 Living Wage Calculator,” MIT Living Wage Calculator, February 1, 2023, <https://livingwage.mit.edu/articles/103-new-data-posted-2023-living-wage-calculator>.

16. Occupations are presented with O*Net Standard Occupational Classifications.
17. Educational Requirements come from the BLS Occupational Outlook Handbook.
18. Median Advertised Wage was derived from Lightcast job postings data.
19. Projected 10-year growth comes from the BLS Occupational Outlook Handbook data.
20. Occupations are presented with O*Net Standard Occupational Classifications.
21. Educational Requirements come from the BLS Occupational Outlook Handbook
22. Median Advertised Wage was derived from Lightcast job postings data.
23. Occupation Snapshot, Lightcast 2023.1, pulled by Meena Naik, March 19, 2023.
24. Occupation Snapshot, Lightcast 2023.1, pulled by Meena Naik, March 19, 2023.
25. Occupations are presented with O*Net Standard Occupational Classifications.
26. Educational Requirements come from the BLS Occupational Outlook Handbook.
27. Median Advertised Wage was derived from Lightcast job postings data.
28. Projected 10-year growth comes from BLS Occupational Outlook Handbook data.
29. *Climate Change and Social Vulnerability in the United States: A Focus on Six Impacts* (Washington, DC: U.S. Environmental Protection Agency, September 2021), https://www.epa.gov/system/files/documents/2021-09/climate-vulnerability_september-2021_508.pdf.
30. Interview with Athena Valenzuela, March 17, 2023.
31. Occupations are presented with O*Net Standard Occupational Classifications.
32. Educational Expectations come from the BLS Occupational Outlook Handbook.
33. Median Advertised Wage was derived from Lightcast job postings data.
34. Projected 10-year growth comes from BLS Occupational Outlook Handbook data.
35. Interview with Jeffrey Cleveland, March 20, 2023.
36. Occupations are presented with O*Net Standard Occupational Classifications.

37. Educational Expectations come from the BLS Occupational Outlook Handbook.
38. Median Advertised Wage was derived from Lightcast job postings data.
39. Projected 10-year growth comes from BLS Occupational Outlook Handbook data.
40. Kaitlyn Henderson, *The Crisis of Low Wages in the U.S.: Who Makes Less Than \$15 an Hour in 2022?* (Boston, MA: Oxfam America, Inc., 2022), https://webassets.oxfamamerica.org/media/documents/low_wage_report_2022_final.pdf.
41. Mansfield, “Together We Can Help Employers,” <https://www.jff.org/points-of-view/raise-job-quality-good-jobs-framework>.
42. Interview with Mark Hall, March 22, 2023.

Interview with Armando Acosta, March 13, 2023.

Interview with Armando Acosta, March 13, 2023.

Stephen Bediako et al., *Worker-Led Research Yields a New Framework for Assessing Job Quality* (Boston, MA: Jobs for the Future, June 2021), <https://jfforg-prod-new.s3.amazonaws.com/media/>

[documents/Worker-Led_Research_Report_072121_AD.pdf](https://jfforg-prod-new.s3.amazonaws.com/media/documents/Worker-Led_Research_Report_072121_AD.pdf).

Bediako et al., *Worker-Led Research*, https://jfforg-prod-new.s3.amazonaws.com/media/documents/Worker-Led_Research_Report_072121_AD.pdf.

Francesca Gino, “How to Make Employees Feel Like They Own Their Work,” *Harvard Business Review*, December 7, 2015, <https://hbr.org/2015/12/how-to-make-employees-feel-like-they-own-their-work>.

“The BLS Green Jobs Definition,” U.S. Bureau of Labor Statistics, accessed May 21, 2023, https://www.bls.gov/green/green_definition.htm.

Green Jobs: Towards Decent Work in a Sustainable, Low-Carbon World (Nairobi, Kenya: United Nations Environment Programme, September 2008), https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_158727.pdf.

Green Jobs, https://www.ilo.org/wcmsp5/groups/public/---ed_emp/---emp_ent/documents/publication/wcms_158727.pdf.



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